CMUT PACKAGING FOR ULTRASOUND SYSTEM

PRIORITY

This application claims priority from U.S. Provisional Application Ser. No. 60/992,020, filed Dec. 3, 2007 and U.S. Provisional Application Ser. No. 61/024,843, filed Jan. 30, 2008.

BACKGROUND

The present application relates to capacitive micromachined ultrasonic transducers (CMUT) and, more particularly to the packaging of CMUT based ultrasonic transducers, devices, and systems

A catheter allows surgical personnel to diagnose and treat conditions deep within a patient's body by navigating the distal end of the catheter to the site where some condition might exist. Then, surgical personnel can operate various sensors, instruments, etc. at the site to perform certain procedures with minimal intrusive effect on the patient. One type of device that has found widespread use is the ultrasonic scanner. Ultrasonic scanners generate acoustic waves at frequencies selected for their ability to allow the acoustic waves to penetrate various tissues and other biological structures and return echoes there from. Often, it is desired to select frequencies on the order of 20 MHz or higher. Images of the tissue surrounding the ultrasonic scanner can be derived from these returned echoes. Another type of ultrasonic device is used to perform High-Intensity Focused Ultrasound (HIFU) through an ultrasonic transducer equipped catheter; it can safely and effectively ablate atrial fibrillation (AF) from the outside surface of a beating heart. Two types of ultrasonic transducers exist, those which are based on piezoelectric crystals (i.e., a crystal fabricated from a piezoelectric material or a piezoelectric composite material) and those based on capacitive micromachined ultrasonic transducers (CMUTs and embedded spring CMUTS or ESCMUTs).

CMUTs typically include two spaced apart electrodes with a membrane attached to one of the two electrodes. In operation, an alternating current (AC) signal is used to charge the electrodes to differing voltages. The differential voltage induces movement of the electrode attached to the membrane and hence, the membrane itself. A piezoelectric transducer (PZTs) also applies an AC signal to the crystal therein causing it to vibrate and produce acoustic waves. The echoes returned to the crystal are used to derive images of the surrounding tissue.

Thus, surgical personnel have found it useful to employ ultrasonic scanner equipped catheters to obtain images of certain tissues (e.g. blood vessels), structures, etc. within human (and animal) patients and to view the effects of therapy thereon. For instance, ultrasonic transducers can provide images which allow medical personnel to determine whether blood is flowing through a particular blood vessel.

Some catheters include a single ultrasonic transducer situated at, or near, the distal end of the catheter whereas other catheters include arrays of ultrasonic transducers at the distal end of the catheter. These ultrasonic transducer transducers can be arrange along the side of the catheter and can point outward there from. If so they can be referred to as "side looking" transducers. When the catheter only has one side looking transducer the catheter can be rotated to obtain images of the tissue in all directions around the catheter. Otherwise, the catheter can have ultrasonic transducers pointed in all directions around the catheter.

In other situations, catheters can have ultrasonic transducers arranged at the distal end of the catheter which point in a distal direction from the end of the catheter. These types of ultrasonic transducers can be referred to as "forward looking" transducers. Forward looking transducers can be useful for obtaining images of tissue in front of (i.e. "forward" of) the catheter.

Since in both ultrasound imaging and ultrasound therapy, the ultrasound system focuses ultrasound in a target zone to achieve either imaging or therapy, a catheter based ultrasound system used for imaging can also be configured to perform therapy by selecting a proper ultrasound frequency and energy input.

SUMMARY

Embodiments provide ultrasonic transducers, device, and systems, (e.g. scanners or HIFU devices) and methods of manufacturing ultrasonic systems. More particularly, a method practiced according to one embodiment includes integrating a flexible electronic device (e.g. an integrated circuit) with a flexible member and integrating a flexible ultrasonic transducer (e.g. a portion of a circular CMUT array) with the flexible member. The integrated flexible electronic device, flexible ultrasonic transducer, and flexible member can form a flexible subassembly which is rolled up to form the ultrasonic transducer. The packaging methods disclosed herein can be used to make miniaturized ultrasonic transducers, devices, and systems. These methods can also be used to make flexible ultrasonic transducers, devices, and systems. Moreover, the resulting ultrasonic transducers, devices, and systems can be mechanically flexible. In some embodiments, these ultrasonic transducers, devices, and systems can also be operationally flexible in that they can be applied to a variety of situations including: IVUS/ICE) imaging and various forms of therapy. For example, these ultrasonic transducers, devices, and systems can be used for, but not limited to, high intensity focused ultrasound (HIFU) ablation for AF on a human patient's heart.

In some embodiments, the integration of the flexible electronic device and the flexible ultrasonic transducer with the flexible member occurs at the same time. Furthermore, the integration of the ultrasonic transducer can be performed from the side of ultrasonic transducer which includes its active surface. In the alternative, the integration of the flexible electronic device can occur before (or after) the integration of the flexible ultrasonic transducer. Moreover, the integration of the flexible ultrasonic transducer can include using a semiconductor technique. In some embodiments, the rolled up flexible subassembly forms a lumen which can be coupled to the lumen of a catheter. However, the rolled up flexible subassembly can be attached to a lumen of a catheter instead. In some embodiments, the method includes folding a portion of the flexible member (which hosts the flexible ultrasonic transducer) through an angle of about ninety degrees to form a forward looking ultrasonic transducer. The flexible member of some embodiments can include a pair of arms attached to portions of a circular array of CMUT transducers. As the arms (and the rest of the flexible member) are rolled up, the circular CMUT array can be folded through about ninety degrees to form a ring shaped CMUT array. The ring shaped CMUT array can then be used as a forward looking CMUT array.

One embodiment of an ultrasonic system disclosed herein includes a flexible electronic device (e.g. an integrated circuit), a flexible ultrasonic transducer; and a flexible member with the flexible electronic device and the flexible ultrasonic transducer integrated with the flexible member. The inte-